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Report No. FAA-RD-76-162

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# SUPPORTING DOCUMENTATION FOR TECHNICAL REPORT ON AIRPORT CAPACITY AND DELAY STUDIES

(Report No. FAA-RD-76-153)

DEPARTMENT OF TRANSPORTATION • UNITED STATES OF AMERICA •

Final Report
June 1976



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Prepared for

**U.S. DEPARTMENT OF TRANSPORTATION**
**FEDERAL AVIATION ADMINISTRATION**
**Systems Research & Development Service**
**Washington, D.C. 20590**

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16. Abstract

This report contains technical data to supplement the report "Technical Report on Airport Capacity and Delay Studies." The report contains supporting documentation of the technical studies leading to the preparation of an airfield capacity and delay handbook for the Federal Aviation Administration.

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# METRIC CONVERSION FACTORS

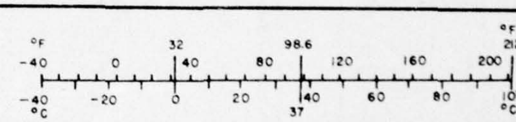
## Approximate Conversions to Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | *2.5 | centimeters | cm |
| ft | feet | 30 | centimeters | cm |
| yd | yards | 0.9 | meters | m |
| mi | miles | 1.6 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 6.5 | square centimeters | $cm^2$ |
| $ft^2$ | square feet | 0.09 | square meters | $m^2$ |
| $yd^2$ | square yards | 0.8 | square meters | $m^2$ |
| $mi^2$ | square miles | 2.6 | square kilometers | $km^2$ |
| | acres | 0.4 | hectares | ha |
| | | **MASS (weight)** | | |
| oz | ounces | 28 | grams | g |
| lb | pounds | 0.45 | kilograms | kg |
| | short tons (2000 lb) | 0.9 | tonnes | t |
| | | **VOLUME** | | |
| tsp | teaspoons | 5 | milliliters | ml |
| Tbsp | tablespoons | 15 | milliliters | ml |
| fl oz | fluid ounces | 30 | milliliters | ml |
| c | cups | 0.24 | liters | l |
| pt | pints | 0.47 | liters | l |
| qt | quarts | 0.95 | liters | l |
| gal | gallons | 3.8 | liters | l |
| $ft^3$ | cubic feet | 0.03 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.76 | cubic meters | $m^3$ |
| | | **TEMPERATURE (exact)** | | |
| °F | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C |

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.


## Approximate Conversions from Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.04 | inches | in |
| cm | centimeters | 0.4 | inches | in |
| m | meters | 3.3 | feet | ft |
| m | meters | 1.1 | yards | yd |
| km | kilometers | 0.6 | miles | mi |
| | | **AREA** | | |
| $cm^2$ | square centimeters | 0.16 | square inches | $in^2$ |
| $m^2$ | square meters | 1.2 | square yards | $yd^2$ |
| $km^2$ | square kilometers | 0.4 | square miles | $mi^2$ |
| ha | hectares (10,000 $m^2$) | 2.5 | acres | |
| | | **MASS (weight)** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.2 | pounds | lb |
| t | tonnes (1000 kg) | 1.1 | short tons | |
| | | **VOLUME** | | |
| ml | milliliters | 0.03 | fluid ounces | fl oz |
| l | liters | 2.1 | pints | pt |
| l | liters | 1.06 | quarts | qt |
| l | liters | 0.26 | gallons | gal |
| $m^3$ | cubic meters | 35 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.3 | cubic yards | $yd^3$ |
| | | **TEMPERATURE (exact)** | | |
| °C | Celsius temperature | 9/5 (then add 32) | Fahrenheit temperature | °F |



## TABLE OF CONTENTS

# Attachment A

## HOURLY DELAYS WITH POISSON AND ERLANG DISTRIBUTIONS

Delays to aircraft in an hour are presented in Figure 2-68 of the Handbook. These delays result from application of the FAA simulation model to typical airfield configurations and demand levels. This attachment presents estimates of delays to aircraft in an hour using probabilistic steady-state queueing models with Poisson and Erlang distributions and compares them with the delays presented in Figure 2-68.

The Poisson distribution is a count distribution that measures the probability of a given number of events occurring within a specified time period. The probability density function for this distribution is:

$$P(x) = \frac{\lambda^x}{x!} e^{-\lambda} \quad \text{if} \quad x = 0, 1, 2, \ldots$$

$$= 0 \quad \text{Otherwise}$$

where

$\lambda$ = average number of events within the specified time period.

The time t from the beginning of the Poisson process until the occurrence of the first event is an exponential random variable. Its probability density function is:

$$f(t) = ue^{-ut} \quad \text{if} \quad t > 0$$

$$= 0 \quad \text{Otherwise}$$

Another distribution that measures the time t until the occurrence of the first event is the Erlang distribution. With parameters k and u, its probability density function is:

$$f(t) = \frac{(uk)^k}{(k-1)!} t^{k-1} e^{-kut} \quad \text{if } t \geqslant 0$$

$$= 0 \quad \text{Otherwise}$$

where

$k = 1, 2, 3, \ldots$

Note that if k = 1, this distribution is identical to the exponential distribution.

Therefore only a single probabilistic queueing model of a general case is needed to investigate delays corresponding to both Poisson (exponential) and Erlang distributions. The model selected to compute average delay to aircraft was developed by Wohl and Martin.* The queueing model has a single station with Poisson arrivals and an Erlang service rate. In the model, delay is calculated by the following equation:

$$d = \frac{(k + 1)\lambda}{2ku(u - \lambda)}$$

where

$d$ = average delay per aircraft per time period

$\lambda$ = average number of aircraft per time period

$u$ = the inverse of the average service time

$k$ = positive integer.

For aircraft operations on the airfield, $\lambda$ represents the demand rate and u represents the capacity. Thus a delay curve for a particular k value and a particular capacity can be drawn by calculating delays for various demand levels. Curves for a number of capacities and k values can be compared with Figure 2-68 by plotting delays calculated from the equation against the ratio of demand divided by capacity.

The smallest value of k is k = 1. As previously noted, if k = 1, the Erlang service rate equals the exponential service rate and the situation reduces to a model with Poisson arrivals and exponential services rates. The largest value of k is $k = \infty$.

If $k = \infty$, then

$$d = \frac{\lambda}{2u(u - \lambda)}$$

---

*Wohl, Martin and Brian Martin, Traffic System Analysis For Engineers and Planners. (San Francisco: McGraw-Hill Book Co., 1967) p. 372.

Comparing the equations for d at $k = 1$ and $k = \infty$ shows that the delay corresponding to a demand $\lambda$ and capacity u for $k = 1$ is half the delay corresponding to a demand $\lambda'(= 2\lambda)$ and capacity $u'$ $(= 2u)$ for $k = \infty$. For example, delay values for a capacity of 60 operations per hour and with $k = \infty$ are the same as values for a capacity of 120 operations per hour and with $k = 1$. Note that this steady-state result is not theoretically consistent with the delays developed by the simulation model and presented in Figure 2-68. Figure 2-68 shows that delay is related to the ratio of demand to capacity and is independent of the level of demand.

Based on the above equations, average delay curves were derived for three capacity values (60, 120, and 240 operations per hour) and two k values (1 and $\infty$). The three capacities are chosen to form an adequate sample of various realistic capacities. The two different k values form the boundaries of the possible range in values of k. The six combinations of capacity and k values form a representative sample of different conditions. As discussed above, the six combinations of capacity and k values reduce to four different curves. Figure 1 presents these four curves on a copy of Handbook Figure 2-68. The primary difference between the curves developed from the queueing model and the curves presented in Figure 2-68 occurs at ratios of demand to capacity close to 1.0. The queueing model indicates that infinite delays occur at a ratio of demand to capacity of 1.0. These delays do not occur in real life and differ significantly from the values presented in Figure 2-68. In addition, the delays from the queueing model require the user to specify capacity and k values rather than a demand profile factor. These requirements increase the data needed for delay calculations and the complexity of the calculation, especially since k has no physical interpretation.

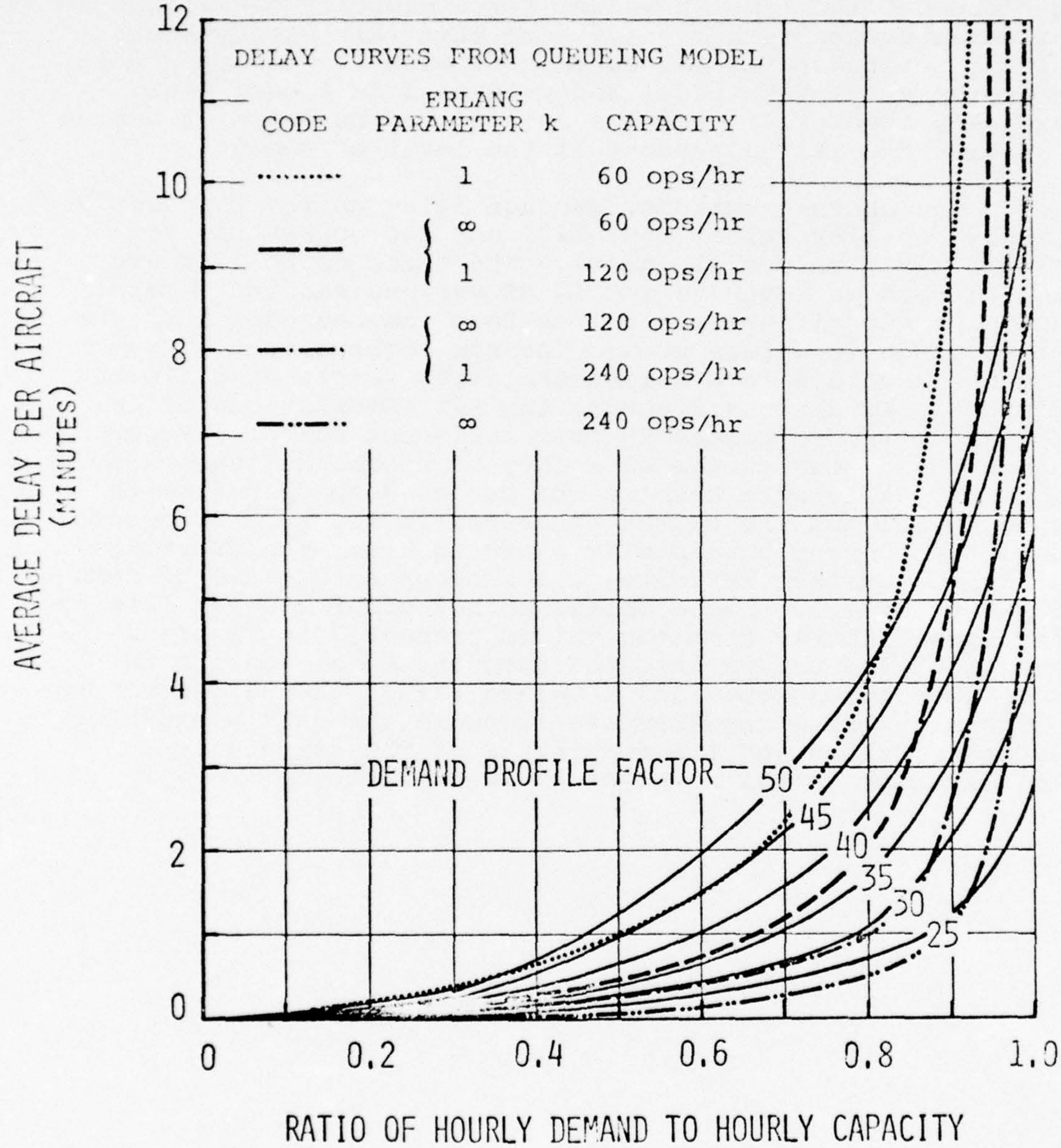



FIGURE I COMPARISON OF AIRCRAFT DELAYS COMPUTED BY QUEUEING MODEL WITH DELAYS FROM HANDBOOK FIGURE 2-68

## Attachment B

## GENERAL GUIDANCE ON MODEL USE

The capacity and delay models should be considered for use in airport planning and evaluation either when the results corresponding to applicable inputs cannot be obtained from the Handbook or when the level of detail of results from the Handbook is not believed to be adequate for the specific investigation.

### Advantages of Model Use

The capacity and delay models are applicable over a broader set of conditions than the Handbook. For example, ATC procedures, runway occupancy times, and other airport specific operating characteristics can be incorporated into the models, whereas certain values were fixed for Handbook presentation purposes. Some situations cannot be dealt with by the Handbook charts (e.g., mix index more than 180, different aircraft classifications, etc.), and the models provide the only means to calculate capacity and delay. Other situations require more details of capacity and delay (e.g., delays by airline, location of congestion, etc.) than the Handbook can provide, and the delay model provides additional capabilities to address these situations.

### Disadvantages of Model Use

The capacity and delay models are quite complex in structure and require significant resources to operate properly. Considerable quantities of model inputs need to be developed to ensure proper model application and these inputs should be obtained from field data, interviews with ATC personnel, etc. Detailed knowledge of model logic is required to (1) ensure choice of the correct model and critical inputs, and (2) obtain full benefit of model use by correctly interpreting model outputs. Most planning situations are well covered by the Handbook, and model use in these situations is normally not justified.

### Resources Required To Operate Models

Skills in airport planning, operations analysis, and computer programming and operation are required to achieve the full benefit of model use. Personnel with these skills should be

familiar with the details of model logic and operation described in the Model User Manual and have access to the model programs in the batch mode.

No specific estimate of man-hours required to set up and operate the models can be given because of the range of problems that can be treated and the variation in capability of individual personnel. However, as a guide, to get an initial understanding of the models and to run a simple trial case requires some two man-weeks for the capacity model and about four man-weeks for the delay model. As familiarity with the techniques increases, the time required per run would reduce.

The cost for computer time varies widely depending on the type of situation modeled. Runs for runway capacity may cost less than five dollars for simple cases, while a run of the delay model for a 16-hour period for a large air carrier airport may cost several hundred dollars.

## Model Accuracy

The logic of the capacity and delay models was designed to be sufficiently accurate for most airfield planning and evaluation situations. Model validation was performed showing results within ±15% of actual field observations. The accuracy depends on the care and resources taken in preparation of the critical model inputs. Model outputs within ±5% of actual field observations can be obtained by fine tuning model inputs to more closely represent actual field conditions.

## Attachment C

## UNOBVIOUS TRENDS IN RUNWAY CAPACITY CURVES

In the runway capacity charts, hourly runway capacity base (C*) is plotted on the vertical axis, mix index is plotted on the horizontal axis, and 3 different curves are shown for 40%, 50%, and 60% arrivals. The shape, gradient, location, and relative displacement of these curves vary from runway use to runway use.

A full explanation of each point on the curves (and hence the shape of the curves) is obtainable from detailed knowledge of each step of the capacity model program and the inputs used in capacity production. The reasons for certain trends in the curves may not be obvious to some Handbook users, while other users more familiar with factors affecting runway capacity may have immediate intuition concerning the reasons for the trends. Reasons for any trend in the curves may be investigated by performing capacity model runs for relevant cases and examining capacity with preemptive arrival priority, the corresponding percent arrivals, and the proportion of the hour other operating strategies are required to obtain the specified percent arrivals.

The unobvious trends referred to in FAA Comment AB15 no longer apply because all graphs have been replotted to reflect new ATC rules, refined inputs, etc.

## ATTACHMENT D

## RUNWAY CAPACITY MODEL INPUTS FOR O'HARE VALIDATION

One of the primary data sources for model validation was collected at Chicago O'Hare International Airport from October 22, 1973 through November 2, 1973. This includes several data sets with landings on runway 27R and departures on runway 32R. The following data sets were selected for validation of the runway capacity model: 408, 410, 412, 413-1, 413-1ARR, 413-2, 417 and 418.

The following summarizes the results of the computer runs and the observed flow rates for these data sets:

| DATA SET | COMPUTED CAPACITY | OBSERVED FLOW RATE |
|---|---|---|
| 408 | 77.6 | 76.2 |
| 410 | 76.5 | 78.0 |
| 412 | 74.3 | 79.6 |
| 413-1 | 78.0 | 85.3 |
| 413-1ARR | 72.2 | 74.4 |
| 413-2 | 77.3 | 83.8 |
| 417 | 74.8 | 77.8 |
| 418 | 75.2 | 77.7 |

The following copy of the computer listing illustrates the inputs used to validate the runway capacity model for these data sets. These model validation runs were performed on June 2, 1975 with the analytical runway capacity model in use at that time.

```
NEWRUN 0 0 0
   6   2

RUNWAY 1 1 0
0.0 0.330.560.11

RUNWAY 2 1 0
0.0 0.050.730.22

ARBAR2 1 2 0
33.070.077.089.0
44.060.066.078.0
32.048.062.067.0
38.051.062.067.0

EXIPT  1 3 0
1.000.0 0.0 0.0
1.000.0 0.0 0.0
0.480.420.100.0
0.170.330.330.17

DLTAIJ 0 4 0
 1.7 1.5 1.9 2.8 0.7 1.5 1.9 2.8 0.4 1.1 1.9 2.8 2.6 3.3 3.6 2.8

APPSPD 0 5 0
 120 120 130 140

DRBAR  0 6 0
  26  29  30  35

TD      0 7 0
  30  40  55  55  30  35  45  50  40  40  50  60 105 105  95  95

GAMMA  0 8 0
   5   5   5   5

TWOIN  011 0
 9001130 1.0 2.0

AICBR  112 0
17.0 8.0 5.0 5.0

DICBR  213 0
15.014.013.013.0
```

```
DA     022 0
 1.4 1.6 1.9 2.0 1.4 1.6 1.9 2.0 1.4 1.6 1.9 2.0 1.4 1.6 1.9 2.0

OTHERS 020 1   ORD DATA SET 408
 6.020.0.040   8   0 0.0 4.03000 3.00.0   0.   45

TWO INTERSECTING, ARR ON =1, DEP ON =2

TO OBTAIN 45 PERCENT ARR, GAPS IN ARRIVAL STREAM MUST EXIST DURING 9 PERCENT OF THE HOUR

               ***  AIRFIELD HOURLY RUNWAY CAPACITY (1973 ATC)  ***
              TOTAL =    77.6  ARRIVAL =    34.9  DEPARTURE =    42.7

OTHERS 020 1   ORD DATA SET 410
 6.020.0.040   8   0 0.0 4.03000 3.00.0   0.   42

RUNWAY 1 1 0
0.0 0.220.670.11

RUNWAY 2 1 1
0.030.190.540.24

TWO INTERSECTING, ARR ON =1, DEP ON =2

TO OBTAIN  42 PERCENT ARR, GAPS IN ARRIVAL STREAM MUST EXIST DURING 16 PERCENT OF THE HOUR

               ***  AIRFIELD HOURLY RUNWAY CAPACITY (1973 ATC)  ***

              TOTAL =    76.5  ARRIVAL =    32.1  DEPARTURE =    44.4

OTHERS 020 0   ORD DATA SET 412
 6.020.0.040   8   0 0.0 4.03000 3.00.0   0.   41

RUNWAY 1 1 0
0.0 0.140.550.31

RUNWAY 2 1 1
0.0 0.030.750.22
```

```
TWO INTERSECTING, ARR ON =1, DEP ON =2

TO OBTAIN  41 PERCENT ARR, GAPS IN ARRIVAL STREAM MUST EXIST DURING  10 PERCENT OF THE HOUR

          ***  AIRFIELD HOURLY RUNWAY CAPACITY (1973 ATC)  ***

         TOTAL =    74.3  ARRIVAL =    30.4 DEPARTURE =     43.8

OTHERS 020 0   ORD DATA SET 413-1
 6.020.0.040   8   0 0.0 4.03000 3.00.0   0.   44

RUNWAY 1 1 0
0.030.130.630.21

RUNWAY 2 1 1
0.030.160.650.16

TWO INTERSECTING, ARR ON =1, DEP ON =2

TO OBTAIN  44 PERCENT ARR, GAPS IN ARRIVAL STREAM MUST EXIST DURING   4 PERCENT OF THE HOUR

          ***  AIRFIELD HOURLY RUNWAY CAPACITY (1973 ATC)  ***

         TOTAL =    78.0  ARRIVAL =    34.3 DEPARTURE =     43.7

OTHERS 020 0   ORD DATA SET 413-1 ARR
 6.020.0.040   8   0 0.0 4.03000 3.00.0   0.   50

RUNWAY 1 1 0
0.040.130.630.20

RUNWAY 2 1 1
0.040.130.630.20

TWO INTERSECTING, ARR ON =1, DEP ON =2

TO OBTAIN  50 PERCENT ARR, AVAILABLE DEPARTURES CAPACITY IS REDUCED BY   6.1 OPERATIONS PER HOUR

          ***  AIRFIELD HOURLY RUNWAY CAPACITY (1973 ATC)  ***

         TOTAL =    72.2  ARRIVAL =    36.1  DEPARTURE =    36.1
```

```
OTHERS 020 0   ORD DATA SET 413-2
 6.020.0.040   8   0 0.0 4.03000 3.00.0   0.   45

RUNWAY 1 1 0
0.050.200.550.20

RUNWAY 2 1 1
0.0 0.170.580.25

TWO INTERSECTING, ARR ON =1, DEP ON =2

TO OBTAIN  45 PERCENT ARR, GAPS IN ARRIVAL STREAM MUST EXIST DURING   3 PERCENT OF THE HOUR

               ***  AIRFIELD HOURLY RUNWAY CAPACITY (1973 ATC)   ***

              TOTAL =    77.3  ARRIVAL =    34.8  DEPARTURE =     42.5


OTHERS 020 0   ORD DATA SET 417
 6.020.0.040   8   0 0.0 4.03000 3.00.0   0.   41

RUNWAY 1 1 0
0.0 0.170.620.21

RUNWAY 2 1 0
0.0 0.140.610.25

TWO INTERSECTING, ARR ON =1, DEP ON =2

TO OBTAIN  41 PERCENT ARR, GAPS IN ARRIVAL STREAM MUST EXIST DURING  14 PERCENT OF THE HOUR

               ***  AIRFIELD HOURLY RUNWAY CAPACITY (1973 ATC)  ***

              TOTAL =    74.8  ARRIVAL =    30.7  DEPARTURE =    44.1


OTHERS 020 0   ORD DATA SET 418
 6.020.0.040   8   0 0.0 4.03000 3.00.0   0.   40

RUNWAY 1 1 0
0.030.410.490.07

RUNWAY 2 1 1
0.0 0.140.610.25
```

TWO INTERSECTING, ARR ON =1, DEP ON =2

TO OBTAIN  40 PERCENT ARR, GAPS IN ARRIVAL STREAM MUST EXIST DURING  24 PERCENT OF THE HOUR

*** AIRFIELD HOURLY RUNWAY CAPACITY (1973 ATC) ***

TOTAL =    75.2  ARRIVAL =    30.1  DEPARTURE =    45.1

# ATTACHMENT E

## CAPACITY MODEL INPUT FOR HANDBOOK PRODUCTION

The handbook (reference 1) contains several sets of graphs for determining the capacity of runways, taxiways, and gates. The technical report (reference 2) defines the inputs used for the taxiway capacity charts in the handbook (Figure 2-65, and 2-66) and for the gate capacity chart in the handbook (Figure 2-67). This attachment defines the inputs used for the runway capacity charts in the handbook.

The basic set of runway capacity charts are Figures 2-3 through 2-64 in Chapter 2 of the handbook. These charts include three factors: hourly capacity base (C), touch and go factor (T), and exit factor (E). In addition, the handbook appendices contain runway capacity charts for special conditions.

The following defines the inputs used for the runway capacity charts:

### 1. CHAPTER TWO RUNWAY CAPACITY CHARTS

#### 1.1 Hourly Capacity Base (C)

Approximately 2000 cases were run during April and May of 1976 to develop the data for the runway capacity charts of Chapter 2 of Reference 1. The following defines the inputs used for these production runs; the inputs are sequenced according to the input type number.

#### Model Number

Input NEWRUN (input type 0) defines the model number. There were 29 different models used for the VFR runs, and 17 different models used for the IFR runs. The following defines the models used for the hourly runway capacity charts.

| VFR Chart No. | VFR Model No. | IFR Chart No. | IFR Model No. |
|---|---|---|---|
| 2-3 | 1,3 | 2-43 | 1,3 |
| 2-4 | 2,20 | 2-44 | 2,20 |
| 2-5 | 2,23 | 2-45 | 2,11 |
| 2-6 | 2,17 | 2-46 | 2,10 |
| 2-7 | 2,22 | 2-47 | 2,4 |
| 2-8 | 2,10 | 2-48 | 2,18 |
| 2-9 | 2,24 | 2-49 | 2,12 |
| 2-10 | 2,18 | 2-50 | 2,6 |
| 2-11 | 3,17 | 2-51 | 3,17 |
| 2-12 | 3,4 | 2-52 | 3,16 |
| 2-13 | 3,5 | 2-53 | 3,6 |
| 2-14 | 3,18 | 2-54 | 3,18 |
| 2-15 | 3,20 | 2-55 | 3,13 |
| 2-16 | 3,9 | 2-56 | 3,11 |
| 2-17 | 3,7 | 2-57 | 4,1 |
| 2-18 | 3,1 | 2-58 thru 2-63 | 6,2 |
| 2-19 | 3,2 | 2-64 | 6,3 |
| 2-20 | 4,1 | | |
| 2-21 | 4,7 | | |
| 2-22 | 4,9 | | |
| 2-23 | 4,15 | | |
| 2-24 | 4,13 | | |
| 2-25 | 4,17 | | |
| 2-26 | 4,19 | | |
| 2-27 thru 2-32 | 6,2 | | |
| 2-33 thru 2-38 | 15,1 | | |
| 2-40 | 13,2 | | |
| 2-41 | 14,1 | | |
| 2-42 | 14,2 | | |

Aircraft Mix

The six different aircraft mixes for RUNWAY (input type 1) used for the production runs were:

| Mix No. | % In Class A | B | C | D | Mix Index |
|---|---|---|---|---|---|
| 1 | 95 | 5 | 0 | 0 | 0 |
| 2 | 60 | 30 | 10 | 0 | 10 |
| 3 | 40 | 35 | 20 | 5 | 35 |
| 4 | 30 | 30 | 30 | 10 | 60 |
| 5 | 15 | 15 | 55 | 15 | 100 |
| 6 | 0 | 10 | 45 | 45 | 180 |

Runway Occupancy Time

The basic runs used the following for ARBAR2 (input type 2)

| | | |
|---|---|---|
| Class | A | 32 seconds |
| | B | 40 seconds |
| | C | 51 seconds |
| | D | 58 seconds |

There were approximately 3,000 additional cases run to determine the exit factor. These are defined in Section 1.3.

Exit Percentage

Since only one value was used for runway occupancy time per aircraft class, the input for EXITPT (input type 3) consists of 1.0 per aircraft class.

Arrival-Arrival Separation Distance

Four different DLTAIJ vectors (input type 4) were used depending upon the weather and mix index. These four vectors are defined as:

| | |
|---|---|
| VFR-GA | (VFR with a mix index $< 20$) |
| VFR-Mixed | (VFR with $20 \geqslant$ mix index $> 50$) |
| VFR-AC | (VFR with mix index $\geqslant 50$) |
| IFR | (IFR for any mix) |

The DLTAIJ vectors (in nautical miles) were:

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VFR-GA | 0.0 | 0.0 | 2.3 | 2.5 | 0.0 | 0.0 | 2.3 | 2.5 | 2.5 | 3.1 | 3.0 | 3.1 | 3.4 | 4.3 | 4.6 | 4.1 |
| VFR-Mixed | 0.0 | 0.0 | 1.8 | 1.9 | 0.0 | 0.0 | 1.8 | 1.9 | 2.4 | 2.9 | 2.5 | 2.5 | 3.5 | 4.2 | 4.1 | 3.5 |
| VFR-AC | 0.0 | 0.0 | 1.2 | 1.3 | 0.0 | 0.0 | 1.2 | 1.3 | 2.1 | 2.6 | 1.9 | 1.9 | 3.2 | 4.1 | 3.5 | 2.9 |
| IFR | 2.3 | 2.1 | 2.3 | 2.5 | 2.3 | 2.1 | 2.3 | 2.5 | 3.8 | 3.6 | 2.3 | 2.3 | 5.8 | 5.6 | 4.6 | 3.5 |

Approach Speed

Four APPSPD vectors (input type 5) were used; the vector identification is the same as for arrival-arrival separation.

The APPSPD vectors (in knots) were:

| | | | | |
|---|---|---|---|---|
| (VFR-GA) | 80 | 100 | 130 | 140 |
| (VFR-Mixed) | 90 | 110 | 130 | 140 |
| (VFR-AC) | 95 | 120 | 130 | 140 |
| (IFR) | 95 | 120 | 130 | 140 |

Departure Runway Occupancy Time

Four DRBAR (input type 6) vectors were used; the vector identification is the same as for arrival-arrival separation.

The DRBAR vectors (in seconds) were:

| | | | | |
|---|---|---|---|---|
| (VFR-GA) | 24 | 29 | 39 | 39 |
| (VFR-Mixed) | 27 | 32 | 39 | 39 |
| (VFR-AC) | 29 | 34 | 39 | 39 |
| (IFR) | 29 | 34 | 39 | 39 |

Departure-Departure Separation Time

The TD (input type 7) vector is dependent upon weather.
The TD vectors (in seconds) were:

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (VFR) | 25 | 30 | 40 | 50 | 30 | 40 | 45 | 50 | 45 | 45 | 55 | 60 | 120 | 120 | 120 | 90 |
| (IFR) | 50 | 50 | 60 | 60 | 55 | 55 | 60 | 60 | 60 | 60 | 60 | 60 | 120 | 120 | 120 | 90 |

Common Approach Path

The length of the common approach path GAMA (input type 7) is dependent upon weather. The GAMA vectors (in nautical miles) were:

| | | | | |
|---|---|---|---|---|
| (VFR) | 1 | 1 | 6 | 6 |
| (IFR) | 6 | 6 | 6 | 6 |

Touch and Go Runway Occupancy Times

The TGRBAR (input type 9) vector (in seconds) was:

23 22 27 27

Open V

Input OPENV (input type 10) was not used for capacity chart production because this input determines whether or not operations are independent and impacts the model selected by certain open V configurations. This model selection was not necessary for Chapter 2 because it is considered in defining the figure number to be used to determine the capacity of each runway use diagram.

Arrival-Departure Separation for Intersecting Runways

The ADSR (input type 12) vector depends upon the distance from threshold to intersection for the arrival runway. The production runs used the following ADSR values (in seconds):

| Distance | A D S R | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 1000 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 2000 | 17 | 17 | 17 | 17 | 8 | 8 | 8 | 8 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 3000 | 32 | 32 | 32 | 32 | 37 | 37 | 37 | 37 | 24 | 24 | 24 | 24 | 19 | 19 | 19 | 19 |
| 4000 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 38 | 38 | 38 | 38 | 35 | 35 | 35 | 35 |
| 5000 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 47 |
| 6000 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 51 | 51 | 51 | 51 | 55 | 55 | 55 | 55 |
| 7000 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 51 | 51 | 51 | 51 | 58 | 58 | 58 | 58 |

Departure-Arrival Separation for Intersecting Runways

The DICBR (input type 13) vector contains 16 identical values. The values are 0 if the arrival runway distance from threshold to intersection exceeds 8000 feet. Otherwise, the values are 1.0 nautical miles if the distance from threshold to intersection of the departure runway is less than 4000 feet, and 2.0 nautical miles if the distance from threshold to intersection for the departure runway is 4,000 feet or more.

Input OTHER

Input OTHER (input type 20) contains all of the standard deviations, the probability of violating separation requirements (PV), departure-arrival separation (DLTADA), visibility (VIS), ceiling (CEIL), glide slope (G.SLOPE), percent touch and go (POTG) and percent arrivals (PA%). All models were run at 40%, 50% and 60% arrivals plus the 9999 case. The following defines the OTHER inputs used for production.

OTHER INPUT DATA

| Weather A/C Mix | SIG MAR | SIG MAA | PV | SIG DR | SIG MAC | DLTA DA | VIS | CEIL | GL SLOPE | POTG | SIG TDR | PA% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VFR-GA | 6.0 | 0.0 | 0.04 | 5 | 0 | 0.0 | 5.0 | 3500 | 3.0 | .00 | 7 | * |
| VFR-Mix | 6.0 | 9.0 | 0.04 | 7 | 0 | 0.0 | 5.0 | 3500 | 3.0 | .00 | 7 | * |
| VFR-AC | 6.0 | 18.0 | 0.04 | 8 | 0 | 0.0 | 5.0 | 3500 | 3.0 | .00 | 7 | * |
| IFR | 6.0 | 15.0 | 0.04 | 8 | 0 | 0.0 | 2.5 | 800 | 3.0 | .00 | 7 | * |

* PA% = 40, 50, 60 and 9999 case.

DDD and BAA

The input for BDD (input Type 22) and BAA (input Type 24) was the same for all runs. The BDD and BAA vectors (seconds) were:

0 0 0 25 0 0 0 20 0 0 0 10 25 20 10 0

1.2 Touch-and-Go Factor (T)

The touch-and-go factor was calculated by a series of runs with models 1-3 and 2-24 (single and two close parallel runways with mixed operations). These runs used the standard VFR inputs; all six mixes; 40, 50, and 60% arrivals; and percent touch-and-go (input POTG of input Type 20) of 5, 10, 20, 30, 40 and 50 percent.

## 1.3 *Exit Factor (E)*

Approximately 3,000 cases were run to develop the exit factors. These runs included:

- 40, 50, and 60 percent arrivals plus the 9999 case.
- models 1-3 and 6-2 (for 6 intersection combinations) in VFR and IFR plus models 2-24 and 15-1 (for 6 intersection combinations) in VFR.
- the following ARBAR2 (input Type 2) values.

ARBAR2

| Aircraft Mix | Aircraft Class A | B | C | D |
|---|---|---|---|---|
| 1,2* | 85.0 | 75.0 | 65.0 | 65.0 |
| 1,2 | 63.9 | 75.0 | 65.0 | 65.0 |
| 1,2 | 40.4 | 71.6 | 65.0 | 65.0 |
| 1,2 | 50.0 | 46.6 | 64.4 | 65.0 |
| 1,2 | 63.0 | 54.0 | 57.8 | 64.2 |
| 1,2 | 79.0 | 68.0 | 58.3 | 59.1 |
| 3,4,5,6 | 115.0 | 104.0 | 91.0 | 91.0 |
| 3,4,5,6 | 82.8 | 104.0 | 91.0 | 91.0 |
| 3,4,5,6 | 41.3 | 98.2 | 91.0 | 91.0 |
| 3,4,5,6 | 50.0 | 50.7 | 89.9 | 91.0 |
| 3,4,5,6 | 63.0 | 54.0 | 74.4 | 89.2 |
| 3,4,5,6 | 79.0 | 68.0 | 59.3 | 63.0 |
| 3,4,5,6 | 95.0 | 84.0 | 73.0 | 73.0 |
| 3,4,5,6 | 105.0 | 94.0 | 82.0 | 82.0 |

* The aircraft mixes are defined in Section 1.1

## 2. APPENDICES

### 2.1 Appendix 1. Preliminary Analysis of Capacity and Delay

The runway capacity tables in Appendix 1 were obtained from values presented in the charts in Chapter 2. The Appendix 1 analysis is defined in the Technical Report (Reference 2) and will not be repeated here.

### 2.2 Appendix 2. Effect of Ceiling and Visibility on Runway Capacity

This appendix presents capacity charts for poor visibility conditions (PVC). The following models were used for the charts in Appendix 2:

| Figure | Model No. | Figure | Model No. |
|---|---|---|---|
| A2-2 | 1-3 | A2-8 | 2-10 |
| A2-3 | 2-20 | A2-9 | 2-4 |
| A2-4 | 2-8 | A2-10 | 2-18 |
| A2-5 | 2-17 | A2-11 | 2-12 |
| A2-6 | 2-11 | A2-12 | 2-6 |
| A2-7 | 2-16 | A2-13,14,15 | 6-2 |

The PVC inputs are identical to the IFR inputs with the following four changes:

ARBAR2 (input Type 2)

| | |
|---|---|
| Class A | 42 seconds |
| Class B | 50 seconds |
| Class C | 61 seconds |
| Class D | 68 seconds |

TD (input Type 7)

60 60 60 60 60 60 60 60 60 60 60 60 120 120 120 90

DICBR (input Type 13)
all 16 values are 2.0

OTHER (input Type 20)

6.0 15.0 0.04 8 0 2.0 0.0 0 3.0 .00 7 %A
where %A is the percent arrivals = 40, 50 and 60 percent.

## 2.3 Appendix 3. Effect of Navigational Aids on Runway Capacity

Special model runs were made for the capacity values in a radar environment with a circling approach. These runs included model 1-3 (for Figure A3-2) and model 2-20 (for Figure A3-3). The standard IFR inputs were used except for the arrival-arrival separation distance. The following defines the DLTAIJ (input Type 4) used for Appendix 3.

4.3 4.1 4.3 4.5 4.3 4.1 4.3 4.5 5.8 5.6 4.3 4.3 7.8 7.6 6.6 5.5

## 3.4 Appendix 4. Evaluation of Runways Without Minimum Exit Runways

The special runs for inadequate exits were made for model 1-3 (single runway with mixed operations), VFR weather, aircraft mix 1 (95% class A and 5% class B), 50 percent arrivals, and touch-and-go percentages of 0, 25, and 50. The arrival and departure runway occupancy times (ARBAR2-input type 2 and DRBAR-input type 6) were modified as defined in the following table:

| | ARBAR 2 Aircraft Class | | DRBAR Aircraft Class | |
|---|---|---|---|---|
| Configuration | A | B | A | B |
| 1 | 94 | 133 | 28 | 24 |
| 2a | 28 | 88 | 83 | 24 |
| 2b | 55 | 88 | 56 | 24 |
| 3 | 42 | 33 | 128 | 124 |
| 4a | 28 | 88 | 28 | 24 |
| 4b | 55 | 88 | 28 | 24 |
| 5a | 32 | 73 | 58 | 24 |
| 5b | 52 | 73 | 38 | 24 |
| 6a | 28 | 33 | 83 | 68 |
| 6b | 42 | 33 | 68 | 68 |

REFERENCES:

1) "Techniques for Determining Airport Airside Capacity and Delay" Contract DOT FA72WA-2897, Final Report, June 1976.

2) "Procedures for Determination of Airport Capacity", Contract DOT FA72WA-2897, Final Report, June 1976.

# ATTACHMENT F

## DESCRIPTION OF COMPUTERIZED HOURLY RUNWAY CAPACITY MODEL (VERSION 2)

Paragraph 32 of Reference 1 defines how to use the computerized technique to determine hourly runway capacity (i.e., the on-line model). The referenced paragraph contains a complete set of instructions for the general user.

This report is written for the more sophisticated users of the computerized hourly runway capacity technique. This report contains two general sections.

1. Special capabilities of the computerized hourly runway capacity technique.

2. The procedure and built-in data used to prepare inputs for the batch hourly runway capacity program.

It is not necessary to understand programming to read this report. However, an understanding of the inputs to the batch hourly runway capacity program is assumed.

### 1. Special Capabilities of the Computerized Hourly Runway Capacity Technique

Reference 1 was written for the airport planner. It did not assume knowledge of the batch program to determine hourly runway capacity. Special capabilities were built into the computerized hourly runway technique (the on-line model) for the sophisticated user. These special capabilities:

- abbreviate the input-output process;
- allow inputs which cannot be obtained with standard techniques;
- obtain a listing of the inputs which were used by the batch hourly runway capacity program.

1.1 Abbreviated Inputs and Outputs. The first question asked after the computer access (log on) process has been completed is: DO YOU WANT A DESCRIPTION AND IMPLEMENTATION SCHEDULE FOR FUTURE ATC SYSTEMS?

Reference 1 states that the reply to this data request is a "y" or an "n". However, it is also possible to enter special instructions which give abbreviated data request statements and/or no input summary. These

abbreviated procedures are designed to expedite use for the sophisticated user. The existence of these special codes are not advertised because they will confuse the infrequent, or first time, user. The valid replies to this data request are:

| Data Response | ATC Description | Full Data Requests | Input Summary |
|---|---|---|---|
| Y or Y X or Y X X (where X is any entry other than N) | yes | yes | yes |
| N or N X or N X X | no | yes | yes |
| Y N or Y N X | yes | no | yes |
| N N or N N X | no | no | yes |
| Y X N | yes | yes | no |
| Y N N | yes | no | no |
| N X N | no | yes | no |
| N N N | no | no | no |

A "yes" for ATC description will provide the following data printout before the next data request is made:

DESCRIPTION OF FUTURE ATC SYSTEMS (JULY 1975)

| | | |
|---|---|---|
| P :: | (1975) | PRESENT ATC WITH ARTS III |
| F1: | (1977-1982) | METEOROLOGICAL ADVISORY SYSTEM |
| F2: | (1978-1983) | WAKE VORTEX PREDICTIVE SYSTEM<br>BASIC METERING AND SPACING |
| G3: | (1980-1990) | WAKE VORTEX PREDICTIVE SYSTEM<br>BASIC METERING AND SPACING<br>DISCRETE ADDRESS BEACON SYSTEM (DABS)<br>MICROWAVE LANDING SYSTEM (MLS) |
| H4: | (1981-1990) | WAKE VORTEX PREDICTIVE SYSTEM<br>ADVANCED METERING AND SPACING<br>DISCRETE ADDRESS BEACON SYSTEM (DABS)<br>MICROWAVE LANDING SYSTEM (MLS)<br>REDUCED MISSED APPROACH/DEPARTURE ZONES<br>HIGH SPEED EXITS |

A "no" for full data requests will provide the following abbreviated data requests in lieu of the full data requests:

| Full Data Request | Abbreviated Data Request |
|---|---|
| ENTER PRESENT OR FUTURE ATC CONFIGURATION (P, F1, F2, G3, H4) | ATC |
| ENTER VFR, IFR OR PVC | WEATHER |
| DO GA AIRCRAFT FLY A SHORT FINAL APPROACH? | SHORT GA FINAL? |
| ENTER RUNWAY USE DIAGRAM NUMBER (1 - 51) | R/W NO. |
| ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D) FOR EACH PRINTED RUNWAY NUMBER | R/W MIX |
| ENTER SEPARATION "S" BETWEEN PARALLEL RUNWAYS (FEET) | SEPARATION S |
| ENTER DISTANCE "X" BETWEEN THRESHOLD AND INTERSECTION FOR EACH PRINTED RUNWAY NUMBER (FEET) | THRESHOLD TO INTERSECTION X |
| ENTER ANGLE "A" BETWEEN NONPARALLEL RUNWAYS (DEGREES) | ANGLE A |
| ENTER DISTANCE "D" BETWEEN THE THRESHOLD AND CENTERLINE OF NONPARALLEL RUNWAY (FEET) | THRESHOLD TO NONPARALLEL D |
| ENTER ARRIVAL PERCENTAGE | ARRIVAL % |
| ENTER TOUCH AND GO PERCENTAGE | T & G % |
| ENTER EXIT DISTANCES AND RUNWAY LENGTH (FT) FOR EACH PRINTED RUNWAY NUMBER. IDENTIFY ANGLED EXITS WITH AN "A" AFTER DISTANCE. ENTER W AFTER RUNWAY LENGTH TO IDENTIFY WET RUNWAY. | EXITS |
| DO YOU WISH TO PERFORM ANOTHER CALCULATION? | ANOTHER CALCULATION? |

A "no" for input summary will eliminate the printing of the input summary.

1.2 Additional Input Flexibility. The data request ENTER PRESENT OR FUTURE ATC CONFIGURATION (P F1 F2 G3 H4) can actually accept the letter P, F, G, H, I or J in combination with a number 0 through 22 or the letter X. The following defines the meaning of these inputs.

The letters represent different conditions defining the lateral separation requirements for independent arrivals and departures and for lateral wake turbulence.

- P for present lateral separation and wake turbulence requirements.
- F also use present lateral separation and wake turbulence requirements.
- G has present lateral separations for arrivals and departures but does not have lateral wake turbulence separation requirements.
- H has independent arrivals and departures at 3500 ft. and present lateral wake turbulence requirements.
- I has independent arrivals and departures at 2500 ft. and present lateral wake turbulence requirements.
- J has independent arrivals and departures at 3500 ft. and no lateral wake turbulence.

The number is a code defining the parameters which control the separation between consecutive arrivals or departures on the same runway:

0 The present ATC system; this number is implied with ATC system P.

1. This is the basic meterological advisory system to overcome wake turbulence separations.
2. This adds basic metering and spacing to wake vortex prediction.
3. This adds MLS and improved surveillance to group 2.
4. This adds DABS, and reduced missed approach zones to group 3.
5. This is a fallback to group 1.

6. This is a fallback to group 2.
7. This is a fallback to group 3.
8. This is a fallback to group 4.
9. This is MITRE input for Present ATC.
10. This is MITRE input for ATC No. 1.
11. This is MITRE input for ATC No. 2.
12. This is MITRE input for ATC No. 3.
13. This is MITRE input for ATC No. 4.
14. This is 1975 ATC.
15. This is 1975 ATC.

The use of X for ATC number will result in four special data requests just after the aircraft mix is defined for each runway. These special data requests are:

ENTER DLTAIJ

ENTER SIGMAA

ENTER PV

ENTER APPROACH SPEEDS

These special data requests allow the sophisticated user to vary some inputs which normally require use of the batch runway capacity program.

1.3 Input Listing. The batch model input data used can be obtained immediately after the terminal types the calculated capacity values. These data are obtained by activating the attention key during or after the terminal types DO YOU WISH TO PERFORM ANOTHER CALCULATION? After activating the attention key, the terminal will type READY; the entry to obtain an input listing is "L INPUT DATA". After the input data is typed, the terminal will again type READY; at this time the program identification code (e.g., ex faa) is entered and the input data sequence is started for the new runway use configuration.

2. Development of Inputs for Batch Runway Capacity Program

Table I identifies the data requests which impact each batch model input parameter. All data requests are identified in Table I and numbered for future reference. The following two data requests do not impact the development of inputs for the batch runway hourly capacity program.

(1) DO YOU WANT A DESCRIPTION AND IMPLEMENTATION SCHEDULE FOR FUTURE ATC SYSTEMS?

(2) DO YOU WISH TO PERFORM ANOTHER CALCULATION?

The following identifies the built-in data and how each input to the batch runway hourly capacity program is developed.

NEWRUN (Data Type No. 0)

The model number is only dependent upon the runway use diagram number (data request 5) and weather (data request 3) unless it is a parallel runway configuration where separation distance S is needed. The following Table defines the VFR and IFR model number for all runway use diagrams where data request 7 (separation between parallel runways) is not made:

| Runway Use Number | Model Number | Runway Use Number | Model Number |
|---|---|---|---|
| 1 | 1, 3 | 34 | 13, 3 |
| 13 | 4, 1 | 35 | 13, 2 |
| 14 | 4, 3 | 36 | 13, 4 |
| 15 | 4, 7 | 37 | 14, 1 |
| 16 | 4, 5 | 38 | 14, 3 |
| 18 | 4, 11 | 39 | 14, 2 |
| 19 | 4, 15 | 40 | 5, 2 |
| 20 | 4, 13 | 41 | 5, 4 |
| 21 | 4, 17 | 42 | 5, 3 |
| 22 | 4, 19 | 43 | 5, 5 |
| 23 | 6, 2 | 44 | 10, 1 |
| 24 | 6, 3 | 45 | 10, 3 |
| 25 | 15, 1 | 46 | 10, 2 |

| Runway Use Number | Model Number | Runway Use Number | Model Number |
|---|---|---|---|
| 26 | 15, 2 | 47 | 10, 4 |
| 29 | 12, 1 | 48 | 11, 1 |
| 30 | 12, 3 | 49 | 11, 3 |
| 31 | 12, 2 | 50 | 11, 2 |
| 32 | 12, 4 | 51 | 11, 4 |

The PVC model is identical to the VFR and IFR model, except that model 6-2 is used in PVC for runway use diagrams 30, 38, 41 and 49.

The model number for all two and three parallel runway configurations (use diagrams 2 through 12), plus diagram 17, 27 and 28 are dependent upon the ATC letter (data request 2a), weather (data request 3), runway use diagram number (data request 5), and parallel separation S (data request 7). The ATC letters define the rules governing the lateral separation for wake turbulence, independent departures, and independent arrivals. (The ATC letter codes are defined in Section 1.2.)

A "condition code" is determined from the ATC letter, the separation "s" (from data request 7) and the weather (data request 3). These are defined in the following table. If the separation is under 700 feet, it is necessary to check the aircraft mix. Hence, for separation between 300 and 699, it is necessary to determine if condition Z exists; condition Z exists if:

- at least one runway has only class A and B aircraft and 500 $<$ separation S $<$ 700 ft.
- at least one runway has only class A aircraft and 300 $<$ separation S $<$ 500 ft.

CONDITION CODES

| ATC Code | Weather | Separation S | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Over 4299 | 3500 to 4299 | 2500 to 3499 | 700 to 2499 | 300 to 699 | | Under 300 |
| | | | | | | Z | not Z | |
| P or F | v | a | b | c | d | d | f | g |
| | i | a | b | c | d | d | f | g |
| | p | a | b | e | f | f | g | g |
| G | v | a | b | c | c | c | f | g |
| | i | a | b | c | c | c | f | g |
| | p | a | b | e | f | f | g | g |
| H | v | a | a | c | c | c | f | g |
| | i | a | a | c | c | c | f | g |
| | p | a | a | e | f | f | g | g |
| I | v | a | a | a | c | c | f | g |
| | i | a | a | a | c | c | f | g |
| | p | a | a | a | f | f | g | g |
| J | v | a | a | c | d | d | f | g |
| | i | a | a | c | d | d | f | g |
| | p | a | a | e | f | f | g | g |

These condition codes are identified as:

a. Independent arrivals and departures.

b. Dependent arrivals, independent departures, no lateral wake turbulence.

c. Dependent arrivals and departures, no lateral wake turbulence.

d. Dependent arrivals and departures, lateral wake turbulence.

e. Same as "d", plus some constraints on the type of operations per runway and on using all runways.

f. Same as "e" with more severe constraints.

g. Severely constrained (this is not used but available for future modifications).

The final selection of the input for NEWRUN depends upon the condition code and the runway use diagram number.

MODEL NUMBER

| Runway Use Diagram No. | CONDITION | | | | | | |
|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | f | g |
| 2 | 2-20 | 2-20 | 2-20 | 2-20 | 1-3 | 1-3 | 1-3 |
| 3 | 2-11 | 2-11 | 2-17 | 2-23 | 1-3 | 1-3 | 1-3 |
| 4 | 2-4 | 2-10 | 2-16 | 2-22 | 1-3 | 1-3 | 1-3 |
| 5 | 2-6 | 2-12 | 2-18 | 2-24 | 2-18 | 1-3 | 1-3 |
| 6 | 3-16 | 3-17 | 3-17 | 3-17 | 2-20 | 2-20 | 2-20 |
| 7 | 3-6 | 3-6 | 3-5 | 3-4 | 2-20 | 2-20 | 2-20 |
| 8 | 3-14 | 3-13 | 3-13 | 3-18 | 2-20* | 2-20* | 2-20* |
| 9 | 3-11 | 3-11 | 3-11 | 3-19 | 2-22 | 2-22 | 2-22 |
| 10 | 3-10 | 3-10 | 3-9 | 3-20 | 2-22* | 2-22* | 2-22* |
| 11 | 3-8 | 3-8 | 3-7 | 3-21 | 2-24 | 2-24 | 2-22 |
| 12 | 3-3 | 3-3 | 3-2 | 3-1 | 2-24 | 2-24 | 2-22 |
| 17 | 4-10 | 4-9 | 3-11 | 3-11 | 3-19 | 3-19 | 2-22 |
| 27 | 7-4 | 7-4 | 7-4 | 7-4 | 1-3 | 1-3 | 1-3 |
| 28 | 2-6 | 7-6 | 2-18 | 7-5 | 1-3 | 1-3 | 1-3 |

*Denotes runways 1 and 2 are interchanged.

RUNWAY (Data Type No. 1)

The input for runway mix is taken directly from the input for aircraft mix percentage per runway (data request 6).

ARBAR 2 (Data Type No. 2)

The runway occupancy time depends upon the weather (data request 3) and the inputs defining location and type of exits (data request 16). The values are obtained by a linear from the values in Table II. The values under the heading "Wet Runways or PVC" are always used if the weather is PVC and/or the letter "w" is entered after the runway length for runway No. 1.

EXITPT (Data Type No. 3)

Runway exit percentage is computed similar to ARBAR2. The values for EXITPT are defined in Table III. These tabled values are XITPT; the EXITPT values are computed by starting with the exit nearest the threshold (the smallest number) and compute:

EITPT = Max (XITPT, EITPT of previous exit) where XITPT is from Table III,

Then:

EXITPT = EITPT - EITPT of previous exit.

DLTAIJ (Data Type No. 4)

If data Request No. 11 (ENTER DLTAIJ) is made, the values of DLTAIJ are taken directly from the response. (Note that this data request is only made in the special conditions defined in Section 1.2.) The airport planner can enter 3.5, or 16 numbers in response to data request 11. A 16 number input is used directly for the 16 values in the DLTAIJ vector. A three number input (called X, Y and Z) is used as follows:

If the weather is VFR (from data request 3)

DLTAIJ = 0.0 0.0 1.2 1.3 0.0 0.0 1.2 1.3 X X X X Z Z Z Y

otherwise

DLTAIJ = X X X X X X X X X X X X Z Z Z Y

A five number input (called J, K, L, M, N) is used as follows:

If the weather is VFR (from data Request 3):

DLTAIJ = 0.0 0.0 1.2 1.3 0.0 0.0 1.2 1.3 K K J J N N M L

otherwise

DLTAIJ = J J J J J J J J K K J J N N M L

If data request number 11 (ENTER DLTAIJ) is not made, the DLTAIJ vector is dependent upon the ATC number, the weather and (in one specific case) the aircraft mix. The aircraft mix is only considered in VFR with ATC number 0. There are 24 possible DLTAIJ vectors; these are defined in Table IV. The selection of the DLTAIJ vector is defined in the following table; for VFR and ATC number 0 use vector 1 if all (% C + 3*% D) < 20; use vector 2 is all (% C + 3*% D) < 50, and at least one (% C + 3*% D) ≥ 20; use vector 3 if any (% C + 3*% D) > 50. The DLTAIJ vectors are defined in Table IV; the following defines the selection of the vector.

DLTAIJ Vector Code No.

| Weather | ATC NUMBER | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | X |
| v | * | 4 | 5 | 6 | 7 | 4 | 5 | 5 | 5 | 13 | 14 | 15 | 16 | 17 | 23 | 23 | ** |
| i | 8 | 9 | 10 | 11 | 12 | 8 | 8 | 10 | 10 | 18 | 19 | 20 | 21 | 22 | 24 | 24 | ** |
| p | 8 | 9 | 10 | 11 | 12 | 8 | 8 | 10 | 10 | 18 | 19 | 20 | 21 | 22 | 24 | 24 | ** |

*For ATC number 0 and weather v:
ATC vector 1, if all (% C+ 3% D) < 20.
ATC vector 2, is all (% C + 3% D) < 50 and at least one (% C + 3% D) ≥ 20.
ATC vector 3, if at least one (% C + 3% D) ≥ 50.
**Use input to data request 11 (ENTER DLTAIJ).

APPSPD (Data Type No. 5)

The four values entered in response to data request 14 are used whenever this data request is used. Otherwise the value of APPSPD depends upon the weather and aircraft mix. In weather i or p, use:

APPSPD = 95 120 130 140,

and use the above in weather v if any (% C + 3*% D) > 50. If weather v with all (% C + 3*% D) < 50 and at least one (% C + 3*% D) ≥ 20, use

APPSPD = 90 110 130 140.

In weather v with all (% C + 3*% D)<20, use

APPSPD = 80 100 130 140

DRBAR (Data Type No. 6)

The departure runway occupancy times depend upon the weather and aircraft mix. In weather i or p (and in weather v with any (% C + 3*% D) ⩾ 50), use

DRBAR = 29 34 39 39

In weather v with all (% C + 3*% D) < 50, and at least one (% C + 3*% D) ⩾ 20, use

DRBAR = 27 32 39 39.

In weather v with all (% C + 3*% D) < 20

DRBAR = 24 29 39 39

TD (Data Type No. 7)

The TD vector is dependent upon the weather and ATC number. There are 12 TD vectors; the selection of the TD vector is based on the following table.

TD VECTOR NUMBER

| Weather | ATC NUMBER | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | X |
| v | 1 | 4 | 4 | 7 | 7 | 1 | 1 | 4 | 4 | 10 | 11 | 11 | 12 | 12 | 1 | 1 | 1 |
| i | 2 | 5 | 5 | 8 | 8 | 2 | 2 | 5 | 5 | 10 | 11 | 11 | 12 | 12 | 2 | 2 | 2 |
| p | 3 | 6 | 6 | 9 | 9 | 3 | 3 | 6 | 6 | 10 | 11 | 11 | 12 | 12 | 3 | 3 | 3 |

The TD vectors are defined in Table V.

GAMA (Data Type No. 8)

The length of the common approach path (GAMA) depends upon the weather (data request 3) and if GA aircraft fly a short final approach (data request 4). If the weather is IFR or PVC data request 4 is not made and,

GAMA = 6 6 6 6

Data request 4 is made in VFR; if a yes response is given to data request 4,

GAMA = 1 1 6 6

If a no response is given to data request 4,

GAMA = 6 6 6 6

If a g response is given to data request 4, a special data request INPUT GAMA is made and the 4 integer response is used for GAMA.

TGRBAR (Data Type No. 9)

The touch and go runway occupancy time is built in and k is independent of all inputs by the airport planner.

TGRBAR = 23 22 27 27

OPEN V (Data Type No. 10)

The values in OPEN V are dependent upon the angle and separation between open v runways (data requests 9 and 10). The values in OPEN V are:

| | | |
|---|---|---|
| θ | = | A (from data request 9) |
| OPENVX | = | Maximum (100, distance D - 500)<br>where distance D is from data request 10 |
| OPENVY | = | distance D |
| Y 13 | = | distance D + 1000 |
| IPROT 1 | = | 0 |
| IPROT 2 | = | 0 |
| IZTHE | = | 1 if $A < 15$ and distance $D < 2500$ |
| | = | 0 otherwise |
| X 13 | = | distance D + 500 |

TWOIN (Data Type No. 11)

The input TWOIN is not used by the present version of the runway capacity model.

ADSR (Data Type No. 12)

The arrival/departure separation requirements for intersecting runways is dependent upon the distance "X" from the threshold to intersection for the arrival runway (Runway No. 1). The values of ADSR are obtained by performing a linear interpolation between the values in Table VI based upon the distance "X" for runway one. All 16 ADSR values equal 40 for runway use diagrams 30, 38, 41, and 49 in PVC.

DICBR (Data Type No. 13)

The departure/arrival separation requirement for intersecting runways depends upon the weather (data request 3) and the intersection distances "X" (data request 8). DICBR = 2.0 n.mi. if the weather is PVC, otherwise it depends only on intersection distances. In VFR and IFR weather, DICBR = 0, if the distance X for Runway 1 is 8000 or greater. If the distance X for Runway 1 is under 8000, it is necessary to determine if the departure runway distance "X" is less than 4000 ft.

DICBR = 1 n.mi. if the distance X for the departure runway is $<$ 4000 ft;

otherwise,

DICBR = 2 n.mi. The departure runway is Runway 2 for runway use diagrams 23 and 24, and Runway 3 for runway use diagrams 25 and 26.

OTHERS (Data Type No. 20)

The arrival percentage is taken directly from data request 15. The touch and go percentage is requested in VFR for runway use diagram 1, 3, 4 and 5; otherwise it is set equal to 0. If special data requests 12 and 13 are made, the inputs for SIGMAA and PV are taken directly from the response. If the response is "S", or the data request is not made, they are from the following:

There are 11 OTHER vectors; these depend upon aircraft mix, ATC number, and weather. These twelve vectors are numbered; vectors 1, 2 and 3 are the only

ones which use aircraft mix. Use vector 1 if all (% C + 3% D) $<$ 20; use vector 2 if all (% C + 3% D) $<$ 50 and at least one (% C + 3% D) $\geqslant$ 20; use vector 3 if any (% C + 3% D) $\geqslant$ 50. The following table defines the selection of the vectors for OTHER:

OTHER Vector Code Selection

| Weather | ATC Number | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | X |
| v | (a) | 3 | 6 | 6 | 9 | 3 | 3 | 6 | 6 | 3 | 3 | 6 | 6 | 9 | 3 | 3 | (b) |
| i | 4 | 4 | 7 | 7 | 10 | 4 | 4 | 7 | 7 | 4 | 4 | 7 | 7 | 10 | 4 | 4 | (c) |
| p | 5 | 5 | 8 | 8 | 11 | 5 | 5 | 8 | 8 | 12 | 12 | 8 | 8 | 11 | 5 | 5 | (d) |

(a) For ATC number 0 and weather v:

Use OTHER vector 1 if all (% C + 3% D) $<$ 20

Use OTHER vector 2 if all (% C + 3% D) $<$ 50 and at least one (% C + 3% D) $\geqslant$ 20

Use OTHER vector 3 if at least one (% C + 3% D) $\geqslant$ 50

(b) Use OTHER vector 3, except for SIGMAA and PV from data requests 12 and 13, respectively.

(c) Use OTHER vector 4, except for SIGMAA and PV from data requests 12 and 13, respectively.

(d) Use OTHER vector 5, except for SIGMAA and PV from data requests 12 and 13, respectively.

The OTHER vectors are defined in Table VII.

BDD (Input Type 22)

BDD is fixed as

0 0 0 25 0 0 0 20 0 0 0 10 25 20 10 0

MODIAS (Input type 23)

This input determines if the super batch procedure is used to determine the interarrival separation. Version 2 of the computerized hourly runway capacity uses FUTCAP instead of super batch. Hence, the input for input type 23 is fixed at 0. The input for FUTCAP is the variable ISTRCH; the development for the input for this variable is discussed after input type 24.

BAA (Input type 24)

BAA is fixed at:

0 0 0 25 0 0 0 20 0 0 0 10 25 20 10 0

ISTRCH (Column 12 of Input type 0)

The FUTCAP subroutine is used to determine interarrival separation if a 1 is entered in column 12 of input type 0 (i.e., ISTRCH = 1). ISTRCH = 1 if:

- ATC letter is G, H, I or J and
- runway use diagram number is 1, 5 (with S $\geq$4300), or 23.

REFERENCES

1) "Techniques for Determining Airport Airside Capacity and Delay". Contract DOT FA72WA-2897, Final Report, June 1976.

TABLE I. DATA REQUEST IMPACT SUMMARY

| DATA REQUEST | WHEN ASKED | | | | | | PARAMETER IMPACTED | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SPECIAL | ALWAYS | VFR ONLY | PARALLEL | INTERECT | OPEN V | 0 NEWRUN | 1 RUNWAY | 2 ARBAR | 3 EXITPT | 4 DLTAIJ | 5 APPSPD | 6 DRBAR | 7 TD | 8 GAMA | 9 TGRBAR | 10 OPEN V | 12 ADSR | 13 DICBR | 20 OTHER | 22 BDD | 23 MODIAS | 24 BAA |
| 1. ATC DESCRIPTION | X | | | | | | | | | | | | | | | | | | | | | | |
| 2. ATC CONFIGURATION | | X | | | | | | | | | | | | | | | | | | | | | |
| 2a. LETTER | | X | | | | | X | | | | | | | | | | | | | | | | |
| 2b. NUMBER | | X | | | | | | | | | X | | | X | | | | | | X | | | |
| 3. WEATHER | | X | | | | | X | | X | X | X | X | X | X | X | | | | X | X | | | |
| 4. SHORT GA FINAL | | | X | | | | | | | | | | | | X | | | | | | | | |
| 5. R/W USE NUMBER | | X | | | | | X | | | | | | | | | | | | | | | | |
| 6. AIRCRAFT MIX % | | X | | | | | | X | | | X | X | X | | | | | | | X | | | |
| 7. PARALLEL SEPARATION(S) | | | | X | | | X | | | | | | | | | | | | | | | | |
| 8. INTERSECTION DIST X | | | | | X | | | | | | | | | | | | | X | X | | | | |
| 9. OPEN V DISTANCE D | | | | | X | | | | | | | | | | | | X | | | | | | |
| 10. ANGLE A | | | | | X | | | | | | | | | | | | X | | | | | | |
| 11. DLTAIJ | X | | | | | | | | | | X | | | | | | | | | | | | |
| 12. SIGMAA | X | | | | | | | | | | | | | | | | | | | X | | | |
| 13. PV | X | | | | | | | | | | | | | | | | | | | X | | | |
| 14. APPROACH SPEED | X | | | | | | | | | | | X | | | | | | | | | | | |
| 15. ARRIVAL PERCENT | | X | | | | | | | | | | | | | | | | | | X | | | |
| 16. TOUCH AND GO % | | | | X | | | | | | | | | | | | | | | | X | | | |
| 17. EXIT DISTANCES | | X | | | | | | | X | X | | | | | | | | | | | | | |
| 18. ANOTHER CALCULATION | X | | | | | | | | | | | | | | | | | | | | | | |
| Fixed Input | | | | | | | | | | | | | | | | X | | | | | X | X | X |

TABLE III

XITPT (Percent)

| Distance, Threshold to Exit (000 ft.) | Wet Runways | | | | Dry Runways | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Regular Exits | | | | High Speed Exits | | | |
| | A | B | C | D | A | B | C | D | A | B | C | D |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 4 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 13 | 0 | 0 | 0 |
| 2 | 60 | 0 | 0 | 0 | 84 | 1 | 0 | 0 | 90 | 1 | 0 | 0 |
| 3 | 96 | 10 | 0 | 0 | 100 | 39 | 0 | 0 | 100 | 40 | 0 | 0 |
| 4 | 100 | 80 | 1 | 0 | 100 | 98 | 8 | 0 | 100 | 98 | 26 | 3 |
| 5 | 100 | 100 | 12 | 0 | 100 | 100 | 49 | 9 | 100 | 100 | 76 | 55 |
| 6 | 100 | 100 | 48 | 10 | 100 | 100 | 92 | 71 | 100 | 100 | 98 | 95 |
| 7 | 100 | 100 | 88 | 64 | 100 | 100 | 100 | 98 | 100 | 100 | 100 | 100 |
| 8 | 100 | 100 | 100 | 93 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 9 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 10 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 11 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

TABLE II
ARBAR2 (SECONDS)

| DISTANCE THRESHOLD TO EXIT (000 Ft.) | WET RUNWAYS | | | | DRY RUNWAYS | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | REGULAR EXITS | | | | HIGH SPEED EXITS | | | |
| | A | B | C | D | A | B | C | D | A | B | C | D |
| 0 | 24 | 27 | 30 | 47 | 24 | 27 | 29 | 34 | 19 | 24 | 35 | 35 |
| 1 | 24 | 27 | 30 | 47 | 24 | 27 | 29 | 34 | 27 | 24 | 35 | 35 |
| 2 | 34 | 27 | 30 | 47 | 34 | 27 | 29 | 34 | 35 | 24 | 35 | 35 |
| 3 | 44 | 37 | 30 | 47 | 44 | 37 | 29 | 34 | 43 | 32 | 35 | 35 |
| 4 | 55 | 47 | 38 | 47 | 55 | 46 | 38 | 38 | 43 | 41 | 35 | 35 |
| 5 | 65 | 56 | 47 | 47 | 65 | 56 | 47 | 47 | 43 | 49 | 44 | 44 |
| 6 | 76 | 65 | 56 | 56 | 76 | 65 | 56 | 56 | 43 | 49 | 54 | 54 |
| 7 | 99 | 99 | 65 | 65 | 76 | 75 | 65 | 65 | 43 | 49 | 63 | 63 |
| 8 | 99 | 99 | 73 | 73 | 76 | 75 | 73 | 73 | 43 | 49 | 63 | 63 |
| 9 | 99 | 99 | 82 | 82 | 76 | 75 | 82 | 82 | 43 | 49 | 63 | 63 |
| 10 | 99 | 99 | 82 | 82 | 76 | 75 | 85 | 85 | 43 | 49 | 63 | 63 |
| 11 | 99 | 99 | 82 | 82 | 76 | 75 | 90 | 90 | 43 | 49 | 63 | 63 |

DLTAIJ VECTORS

TABLE IV

| Vector Code | Aircraft Type Sequence | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AA | AB | AC | AD | BA | BB | BC | BD | CA | CB | CC | CD | DA | DB | DC | DD |
| 1 | 0.0 | 0.0 | 2.3 | 2.5 | 0.0 | 0.0 | 2.3 | 2.5 | 2.5 | 3.1 | 3.0 | 3.1 | 3.4 | 4.3 | 4.6 | 4.1 |
| 2 | 0.0 | 0.0 | 1.8 | 1.9 | 0.0 | 0.0 | 1.8 | 1.9 | 2.4 | 2.9 | 2.5 | 2.5 | 3.5 | 4.2 | 4.1 | 3.5 |
| 3 | 0.0 | 0.0 | 1.2 | 1.3 | 0.0 | 0.0 | 1.2 | 1.3 | 2.1 | 2.6 | 1.9 | 1.9 | 3.2 | 4.1 | 3.5 | 2.9 |
| 4 | 0.0 | 0.0 | 1.2 | 1.3 | 0.0 | 0.0 | 1.2 | 1.3 | 2.1 | 2.6 | 1.9 | 1.9 | 3.2 | 4.1 | 3.5 | 2.7 |
| 5 | 0.0 | 0.0 | 1.2 | 1.3 | 0.0 | 0.0 | 1.2 | 1.3 | 2.1 | 2.6 | 1.9 | 1.9 | 3.2 | 4.1 | 3.5 | 2.7 |
| 6 | 0.0 | 0.0 | 1.2 | 1.3 | 0.0 | 0.0 | 1.2 | 1.3 | 2.1 | 2.5 | 1.9 | 1.9 | 3.2 | 4.1 | 3.2 | 2.3 |
| 7 | 0.0 | 0.0 | 1.2 | 1.3 | 0.0 | 0.0 | 1.2 | 1.3 | 2.1 | 2.1 | 1.9 | 1.9 | 3.2 | 3.4 | 2.7 | 2.1 |
| 8 | 2.3 | 2.1 | 2.3 | 2.5 | 2.3 | 2.1 | 2.3 | 2.5 | 3.8 | 3.6 | 2.3 | 2.3 | 5.8 | 5.6 | 4.6 | 3.5 |
| 9 | 2.3 | 2.1 | 2.3 | 2.5 | 2.3 | 2.1 | 2.3 | 2.5 | 3.8 | 3.6 | 2.3 | 2.3 | 5.0 | 5.0 | 4.0 | 3.0 |
| 10 | 2.3 | 2.1 | 2.3 | 2.5 | 2.3 | 2.1 | 2.3 | 2.5 | 3.5 | 3.5 | 2.3 | 2.3 | 5.0 | 5.0 | 4.0 | 3.0 |
| 11 | 2.3 | 2.1 | 2.3 | 2.5 | 2.3 | 2.1 | 2.3 | 2.5 | 2.9 | 2.9 | 2.3 | 2.3 | 4.4 | 4.4 | 3.5 | 2.6 |
| 12 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.4 | 2.4 | 2.0 | 2.0 | 3.7 | 3.7 | 3.0 | 2.3 |
| 13 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 2.7 | 2.7 | 1.9 | 1.9 | 4.5 | 4.5 | 3.6 | 2.7 |
| 14 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 2.7 | 2.7 | 1.9 | 1.9 | 4.5 | 4.5 | 3.6 | 2.7 |
| 15 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 2.7 | 2.7 | 1.9 | 1.9 | 4.5 | 4.5 | 3.6 | 2.7 |
| 16 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 2.5 | 2.5 | 1.9 | 1.9 | 4.1 | 4.1 | 3.2 | 2.3 |
| 17 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 2.1 | 2.1 | 1.9 | 1.9 | 3.4 | 3.4 | 2.7 | 2.1 |
| 18 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 3.0 | 6.0 | 6.0 | 5.0 | 4.0 |
| 19 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 3.0 | 5.0 | 5.0 | 4.0 | 3.0 |
| 20 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.5 | 3.5 | 3.0 | 3.0 | 5.0 | 5.0 | 4.0 | 3.0 |
| 21 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.9 | 2.9 | 2.5 | 2.5 | 4.4 | 4.4 | 3.5 | 2.6 |
| 22 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.4 | 2.4 | 2.0 | 2.0 | 3.7 | 3.7 | 3.0 | 2.3 |
| 23 | 0.0 | 0.0 | 1.2 | 1.3 | 0.0 | 0.0 | 1.2 | 1.3 | 0.2 | 1.4 | 1.9 | 1.9 | 3.2 | 4.1 | 3.5 | 2.9 |
| 24 | 2.3 | 2.1 | 2.3 | 2.5 | 2.3 | 2.1 | 2.3 | 2.5 | 2.3 | 2.2 | 2.3 | 2.3 | 4.2 | 4.1 | 4.0 | 3.0 |

## TABLE V

## TD VECTORS

| Code No. | Aircraft Type Sequence | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AA | AB | AC | AD | BA | BB | BC | BD | CA | CB | CC | CD | DA | DB | DC | DD |
| 1 | 25 | 30 | 40 | 50 | 30 | 40 | 45 | 50 | 45 | 45 | 55 | 60 | 120 | 120 | 120 | 90 |
| 2 | 50 | 50 | 60 | 60 | 55 | 55 | 60 | 60 | 60 | 60 | 60 | 60 | 120 | 120 | 120 | 90 |
| 3 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 120 | 120 | 120 | 90 |
| 4 | 25 | 30 | 40 | 50 | 30 | 40 | 45 | 50 | 45 | 45 | 55 | 60 | 90 | 90 | 90 | 60 |
| 5 | 50 | 50 | 60 | 60 | 55 | 55 | 60 | 60 | 60 | 60 | 60 | 60 | 90 | 90 | 90 | 60 |
| 6 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 90 | 90 | 90 | 60 |
| 7 | 25 | 30 | 40 | 50 | 30 | 40 | 45 | 50 | 45 | 45 | 55 | 60 | 60 | 60 | 60 | 60 |
| 8 | 50 | 50 | 60 | 60 | 55 | 55 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| 9 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| 10 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 120 | 120 | 120 | 90 |
| 11 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 90 | 90 | 90 | 60 |
| 12 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |

TABLE VI

INPUT DATA ADSR

LINEAR INTERPOLATION

| Distance Y | ADSR | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AA | AB | AC | AD | BA | BB | BC | BD | CA | CB | CC | CD | DA | DB | DC | DD |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1,000 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 2,000 | 17 | 17 | 17 | 17 | 8 | 8 | 8 | 8 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 3,000 | 32 | 32 | 32 | 32 | 37 | 37 | 37 | 37 | 24 | 24 | 24 | 24 | 19 | 19 | 19 | 19 |
| 4,000 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 38 | 38 | 38 | 38 | 35 | 35 | 35 | 35 |
| 5,000 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 47 |
| 6,000 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 51 | 51 | 51 | 51 | 55 | 55 | 55 | 55 |
| 7,000 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 51 | 51 | 51 | 51 | 58 | 58 | 58 | 58 |
| 8,000 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 51 | 51 | 51 | 51 | 58 | 58 | 58 | 58 |
| 9,000 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 51 | 51 | 51 | 51 | 58 | 58 | 58 | 58 |
| 10,000 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 51 | 51 | 51 | 51 | 58 | 58 | 58 | 58 |

TABLE VII

OTHER VECTORS

| CODE NO. | SIGMAR | SIGMAA | PV | SIGM DR | SIGM AC | DLTA DA | VIS | CEIL | G. SLOPE | P OTG | SIGT GR | PA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.0 | 0.0 | 0.04 | 5 | 0 | 0.0 | 5.0 | 3500 | 3.0 | Input | 7 | Input |
| 2 | 6.0 | 9.0 | 0.04 | 7 | 0 | 0.0 | 5.0 | 3500 | 3.0 | Input | 7 | Input |
| 3 | 6.0 | 18.0 | 0.04 | 8 | 0 | 0.0 | 5.0 | 3500 | 3.0 | Input | 7 | Input |
| 4 | 6.0 | 15.0 | 0.04 | 8 | 0 | 0.0 | 2.5 | 800 | 3.0 | .00 | 7 | Input |
| 5 | 6.0 | 15.0 | 0.04 | 8 | 0 | 2.0 | 0.0 | 0 | 3.0 | .00 | 7 | Input |
| 6 | 6.0 | 11.0 | 0.01 | 8 | 0 | 0.0 | 5.0 | 3500 | 3.0 | Input | 7 | Input |
| 7 | 6.0 | 11.0 | 0.01 | 8 | 0 | 0.0 | 2.5 | 800 | 3.0 | .00 | 7 | Input |
| 8 | 6.0 | 11.0 | 0.01 | 8 | 0 | 2.0 | 0.0 | 0 | 3.0 | .00 | 7 | Input |
| 9 | 6.0 | 8.0 | 0.01 | 8 | 0 | 0.0 | 5.0 | 3500 | 3.0 | Input | 7 | Input |
| 10 | 6.0 | 8.0 | 0.01 | 8 | 0 | 0.0 | 2.5 | 800 | 3.0 | .00 | 7 | Input |
| 11 | 6.0 | 8.0 | 0.01 | 8 | 0 | 2.0 | 0.0 | 0 | 3.0 | .00 | 7 | Input |
| 12 | 6.0 | 11.0 | 0.04 | 8 | 0 | 2.0 | 0.0 | 0 | 3.0 | .00 | 7 | Input |

ATTACHMENT G

# DESCRIPTION OF COMPUTERIZED ANNUAL DELAY MODEL

Paragraph 33 of reference 1 defines how to use the computerized technique to determine annual delay. There are no special codes built into the computerized annual delay technique, as there are in the computerized hourly runway capacity technique.

This attachment defines how the computerized annual delay model prepares the inputs for the delay aggregation program, and defines the built-in data.

## 1. DELAY AGGREGATION PROGRAM INPUT

Annual Demand (Input type No.1)

The input is the integer entered in response to ENTER ANNUAL DEMAND.

Group Specification (Input type No.2)

This input is fixed at 7 day groups, 12 week groups, 3 weather groups, and 6 runway uses per weather group.

Week Percent (Input type No.3)

This input has twelve values (one per month). Each month's value is the input percent of annual operations divided by the number of weeks in the month.

Week Number (Input type No.4)

The 12 values of this input are fixed at the number of weeks for each month. Months with 31 days have 4.430 weeks, months with 30 days have 4.290 weeks, and February has 4.000 weeks.

Day Percent (Input type No.5)

There are seven values for this input type which give the input percent of the weeks operations per day.

Day Number (Input type No.6)

There are seven values for this input type, each value is 1.

Weather Demand Percent (Input type No.7)

There are three values for this input type; the first value is 1.0, the second and third values are from the response to ENTER IFR AND PVC OPERATIONS AS A PERCENT OF VFR OPERATIONS.

Weather Occurrence Percent (Input type No.8)

This input has three rows of data; the first row is for VFR, the second row is for IFR, and the third row is for PVC; there are twelve values per row (one value per month). These are the input values defining PERCENT OF MONTH WHICH IS VFR, IFR, AND PVC.

Capacity Value (Input type No.9)

There are six rows of data for this input, each row has three entries (the first for VFR, the second is IFR, and the third is PVC). This format is used for input types 10, 14, and 15. The first row is the input hourly runway capacity for the first runway use for each of VFR, IFR, and PVC. If there are less than six runway uses for one or more of the weather categories, the program will use a value of 50 as the capacity; however, this value does not impact the annual delay due to the procedure for input type No.10.

Runway Use Occurrence (Input type No.10)

There are six rows of data and three values per row (as there are for input types 9, 14 and 15). If there are less than six VFR, (or IFR or PVC) runway uses defined by the user the unused runway uses will have a zero use occurrence.

Hourly Percent (Input type No.11)

There are 24 values for this input type; these are the 24 values which define each hour's percent of daily operations.

Demand Profile (Input type 12)

The single entry for this input type is the user supplied demand profile factor. The only acceptable input is 25, 30, 35, 40, 45 or 50.

Runway Demand Percent (Input type No.13)

This input type has two values, both are 1.000.

Mix Index (Input type No.14)

This input type has 6 rows with three entries per row (similar to input types 9, 10, and 15). These are the mix indices specified by the user.

Figure Numbers (Input type No.15)

This input type has 6 rows with three entries per row (similar to input types 9, 10, and 14). The input values are based upon the user identified runway use diagram number. However, these runway use diagram numbers must be transformed to the capacity chart numbers used by annual delay aggregation program. The runway use diagram numbers are transformed to capacity chart numbers according to the relationships presented in Figure 2-2 of reference 1; the PVC transformation is the same as the IFR transformation.

2. BUILT-IN DATA

The computerized annual delay technique has built-in data for: monthly demand profile and monthly weather percentages, weekly demand profiles, and daily demand profiles. These built-in data are accessed by entering a letter code(s) for the first value; the procedure is defined in paragraph 33 of reference 1. The data base for these built-in data are defined in reference 1; the data contained in these built-in distributions are defined in the enclosed tables.

REFERENCES

1) "Techniques for Determining Airport Airside Capacity and Delay", Contract DOT FA72WA-2897, Final Report, June 1976.

COMPUTERIZED ANNUAL DELAY

Built-In Data

Monthly Demand Profile and Weather

| | MONTHLY DEMAND (% OF ANNUAL) | | | | | | | MONTHLY WEATHER (% VFR, IFR, AND PVC) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | a | | | b | | | c | | | d | | |
| Month | a | b | c | d | e | f | g | VFR | IFR | PVC | V | I | P | V | I | P | V | I | P |
| Jan | 8.3 | 8.0 | 7.8 | 7.7 | 7.6 | 7.8 | 5.3 | 98 | 2 | 0 | 88 | 10 | 2 | 84 | 15 | 1 | 80 | 18 | 2 |
| Feb | 8.3 | 7.6 | 7.1 | 7.4 | 6.7 | 7.6 | 6.8 | 98 | 2 | 0 | 89 | 9 | 2 | 87 | 12 | 1 | 82 | 14 | 4 |
| Mar | 8.3 | 8.1 | 8.1 | 7.4 | 8.3 | 7.5 | 8.3 | 98 | 2 | 0 | 91 | 7 | 2 | 86 | 13 | 1 | 87 | 11 | 2 |
| Apr | 8.3 | 8.0 | 8.1 | 8.0 | 8.3 | 9.7 | 9.5 | 99 | 1 | 0 | 96 | 4 | 0 | 86 | 13 | 1 | 85 | 13 | 2 |
| May | 8.3 | 8.2 | 8.4 | 8.1 | 8.5 | 9.4 | 9.5 | 99 | 1 | 0 | 96 | 4 | 0 | 87 | 11 | 2 | 84 | 13 | 3 |
| June | 8.4 | 8.7 | 8.7 | 8.7 | 8.6 | 9.4 | 9.2 | 100 | 0 | 0 | 98 | 2 | 0 | 89 | 10 | 1 | 80 | 19 | 1 |
| July | 8.4 | 8.8 | 9.0 | 9.1 | 8.7 | 9.7 | 10.6 | 100 | 0 | 0 | 98 | 2 | 0 | 91 | 8 | 1 | 78 | 21 | 1 |
| Aug | 8.4 | 8.9 | 9.0 | 9.4 | 8.8 | 8.4 | 10.0 | 100 | 0 | 0 | 99 | 1 | 0 | 90 | 9 | 1 | 77 | 22 | 1 |
| Sept | 8.4 | 8.7 | 8.7 | 9.4 | 8.8 | 7.9 | 11.5 | 100 | 0 | 0 | 97 | 3 | 0 | 91 | 8 | 1 | 76 | 21 | 3 |
| Oct | 8.3 | 8.7 | 8.7 | 9.4 | 8.5 | 8.3 | 7.5 | 99 | 1 | 0 | 94 | 5 | 1 | 87 | 12 | 1 | 71 | 25 | 4 |
| Nov | 8.3 | 8.2 | 8.4 | 8.0 | 7.8 | 7.6 | 6.6 | 98 | 2 | 0 | 95 | 4 | 1 | 90 | 9 | 1 | 77 | 20 | 3 |
| Dec | 8.3 | 8.1 | 8.0 | 7.4 | 7.4 | 6.8 | 5.2 | 99 | 1 | 0 | 90 | 8 | 2 | 89 | 10 | 1 | 78 | 19 | 3 |

# ANNUAL DELAY

## Built-In Data

### Daily Demand Profiles

| Day of Week | a | b | c | d | e | f |
|---|---|---|---|---|---|---|
| Monday | .142 | .15 | .15 | .15 | .155 | .10 |
| Tuesday | .143 | .13 | .13 | .12 | .10 | .10 |
| Wednesday | .143 | .14 | .13 | .12 | .12 | .10 |
| Thursday | .143 | .14 | .14 | .13 | .145 | .10 |
| Friday | .143 | .15 | .16 | .18 | .17 | .10 |
| Saturday | .143 | .14 | .14 | .14 | .15 | .25 |
| Sunday | .143 | .15 | .15 | .16 | .16 | .25 |

Built-In Data

Hourly Demand Profiles

| Hour | a | b | c | d | e | f | g | h | i |
|---|---|---|---|---|---|---|---|---|---|
| 0-1 | 0.00 | 2.27 | 2.20 | 1.87 | 1.76 | 0.69 | 0.59 | 0.33 | 0.00 |
| 1-2 | 0.00 | 1.81 | 1.72 | 1.14 | 1.03 | 0.55 | 0.47 | 0.28 | 0.00 |
| 2-3 | 0.00 | 1.19 | 1.11 | 0.78 | 0.61 | 0.28 | 0.23 | 0.16 | 0.00 |
| 3-4 | 0.00 | 0.92 | 0.85 | 0.51 | 0.46 | 0.19 | 0.17 | 0.10 | 0.00 |
| 4-5 | 0.00 | 0.55 | 0.51 | 0.25 | 0.10 | 0.07 | 0.08 | 0.00 | 0.00 |
| 5-6 | 0.00 | 0.74 | 0.69 | 0.42 | 0.27 | 0.12 | 0.12 | 0.03 | 0.00 |
| 6-7 | 0.00 | 1.53 | 1.44 | 0.89 | 0.84 | 0.45 | 0.32 | 0.19 | 0.00 |
| 7-8 | 6.25 | 4.11 | 3.76 | 3.77 | 3.11 | 1.74 | 2.50 | 1.00 | 0.34 |
| 8-9 | 6.25 | 6.47 | 6.68 | 6.96 | 7.34 | 8.65 | 8.63 | 10.24 | 11.25 |
| 9-10 | 6.25 | 6.09 | 6.05 | 6.39 | 6.51 | 7.60 | 7.13 | 7.40 | 8.23 |
| 10-11 | 6.25 | 4.69 | 4.31 | 4.54 | 4.10 | 2.63 | 3.34 | 1.93 | 0.99 |
| 11-12 | 6.25 | 5.73 | 5.58 | 5.92 | 5.85 | 6.72 | 6.01 | 6.21 | 5.63 |
| 12-13 | 6.25 | 5.28 | 5.03 | 5.69 | 5.22 | 5.65 | 4.32 | 3.20 | 2.90 |
| 13-14 | 6.25 | 5.56 | 5.26 | 5.78 | 5.60 | 6.22 | 5.18 | 4.90 | 4.01 |
| 14-15 | 6.25 | 5.16 | 4.67 | 4.79 | 4.51 | 3.60 | 3.77 | 2.45 | 1.73 |
| 15-16 | 6.25 | 5.18 | 4.92 | 5.16 | 4.89 | 4.81 | 4.18 | 2.78 | 2.39 |
| 16-17 | 6.25 | 6.23 | 6.44 | 6.55 | 6.83 | 8.17 | 7.84 | 8.22 | 9.48 |
| 17-18 | 6.25 | 6.93 | 8.11 | 8.33 | 9.74 | 10.82 | 12.21 | 14.91 | 18.00 |
| 18-19 | 6.25 | 6.51 | 7.00 | 7.26 | 8.05 | 9.37 | 9.80 | 12.61 | 12.72 |
| 19-20 | 6.25 | 6.69 | 7.56 | 7.60 | 8.45 | 9.96 | 10.66 | 13.70 | 15.03 |
| 20-21 | 6.25 | 5.94 | 5.80 | 6.13 | 6.15 | 7.35 | 6.86 | 6.83 | 6.62 |
| 21-22 | 6.25 | 4.28 | 4.16 | 4.16 | 3.53 | 2.04 | 2.91 | 1.31 | 0.65 |
| 22-23 | 6.25 | 3.20 | 3.24 | 2.94 | 2.91 | 1.39 | 1.66 | 0.71 | 0.03 |
| 23-24 | 0.00 | 2.94 | 2.91 | 2.17 | 2.14 | 0.93 | 1.02 | 0.51 | 0.00 |